

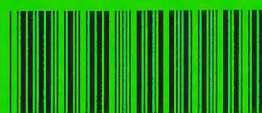
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 **brush**

Oscillograph
Model RD 2361 00

OPERATING INSTRUCTIONS

MP MASTER



MA34684



Oscillograph
Model RD 2361 00

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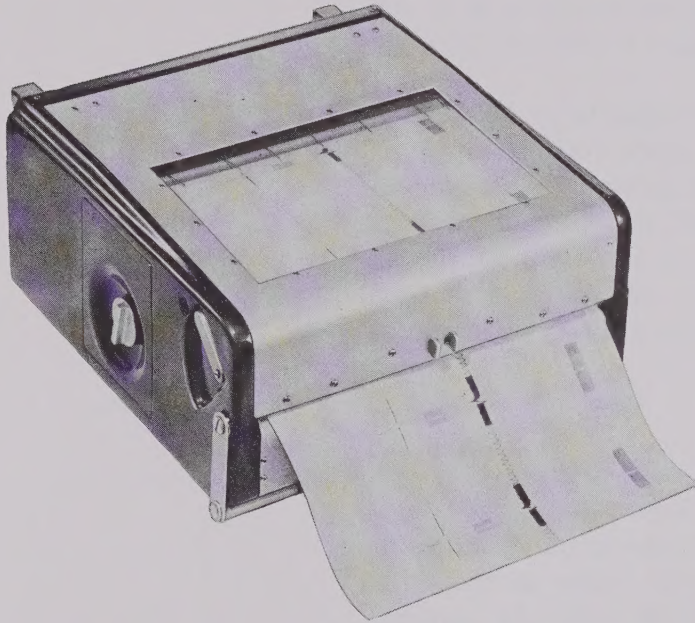
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Section I

General Information



Brush Portable Six Channel Oscillograph, Model RD 2361 00

GENERAL INFORMATION

This direct writing oscillograph provides a means of instantaneously recording, in permanent form, a wide variety of electrical phenomena. It is designed for bench or table-top applications and can be readily moved from place to place. It is designed to operate with the Brush RD series amplifiers. These amplifiers, when matched to the oscillograph, provide a flat frequency response from D.C. to 100 cps.

Recording on one chart facilitates "time" correlation of the various phenomena under observation. The tips of the pens or styli may be seen at all times as the recording is being made.

Chart paper speeds of 1, 2, 5, 10, 25, 50, 125, and 250 millimeters per second are standard. When equipped with an accessory slow speed motor, eight additional chart paper speeds are available in the same multiples, but at centimeters per hour.

For electric writing, an accessory Remote Control Box, Model RA2403-02, is available. Accessory Event Markers are also available. A complete description of all accessories will be found in Section IV - Supplies and Accessories.

General Information

SPECIFICATIONS

The following specifications are applicable to these oscillographs when used with either ink pen, Model RA2821-30, or with stylus,

Model RA2822-30, for electric writing and when properly matched with Brush amplifiers.

D.C. Sensitivity	Approximately 30 volts will produce a deflection of 20 mm from chart center (full scale); 1.5 volts per mm; 1.1 ma per mm.
Measured Trace Linearity	D.C. within 1% of full chart width; A.C. within 2% of full chart width, any frequency up to 100 cps for ink writing. Deviations are measured from a straight line drawn through the origin and the point of maximum deflection (20 mm D.C. 40 mm A.C.) on a plot of pen deflection versus penmotor input voltage.
Channel Width	40 mm (40 divisions)
Frequency Response	Recorded peak-to-peak amplitude of a constant voltage sine wave will be within $\pm 1/2$ chart line (mm) of nominal 40 lines from D.C. to 10 cps or within ± 1 chart line (mm) of a nominal 10 lines from D.C. to 100 cps.
Maximum Amplitude	40 lines (mm) peak-to-peak, to 40 cps. 20 lines (mm) peak-to-peak, to 70 cps. 10 lines (mm) peak-to-peak, to 100 cps.
Chart Speeds	
Standard	1, 2, 5, 10, 25, 50, 125, and 250 mm per second.
Slow Speed Drive	1, 2, 5, 10, 25, 50, 125, and 250 cm per hour. Chart speeds may be instantaneously selected by turning a switch on the panel or at remote locations.
D.C. Resistance of Penmotor	1400 ohms

General Information

Operating Temperature Range	-40°F to +135°F (electric writing) -20°F to +135°F (low temperature ink).
Trace Width	
Ink Writing	0.015 inch with Pen, Model RA2821-30 NOTE: Special fine line pen available with trace width of 0.010 inch.
Electric Writing	0.005 inch with Stylus, Model RA2822-30.
Chart Speed Regulation	Better than 1/4% at constant line frequency.
Paper Drift	Less than $\pm 1/3$ mm.
Power Requirements	105-125 volts, 60 cps, 50 watts, maximum at 115 volts (ink writing). 105-125 volts, 60 cps, 95 watts, maximum at 115 volts (electric writing).
Dimensions	7 inches high, 15 inches wide, 17 inches deep, overall.
Net Weight	51 pounds.
Shipping Weight	63 pounds. Separate carton 20 pounds. Carton contains Junction Box, cables, pens, etc.

General Information

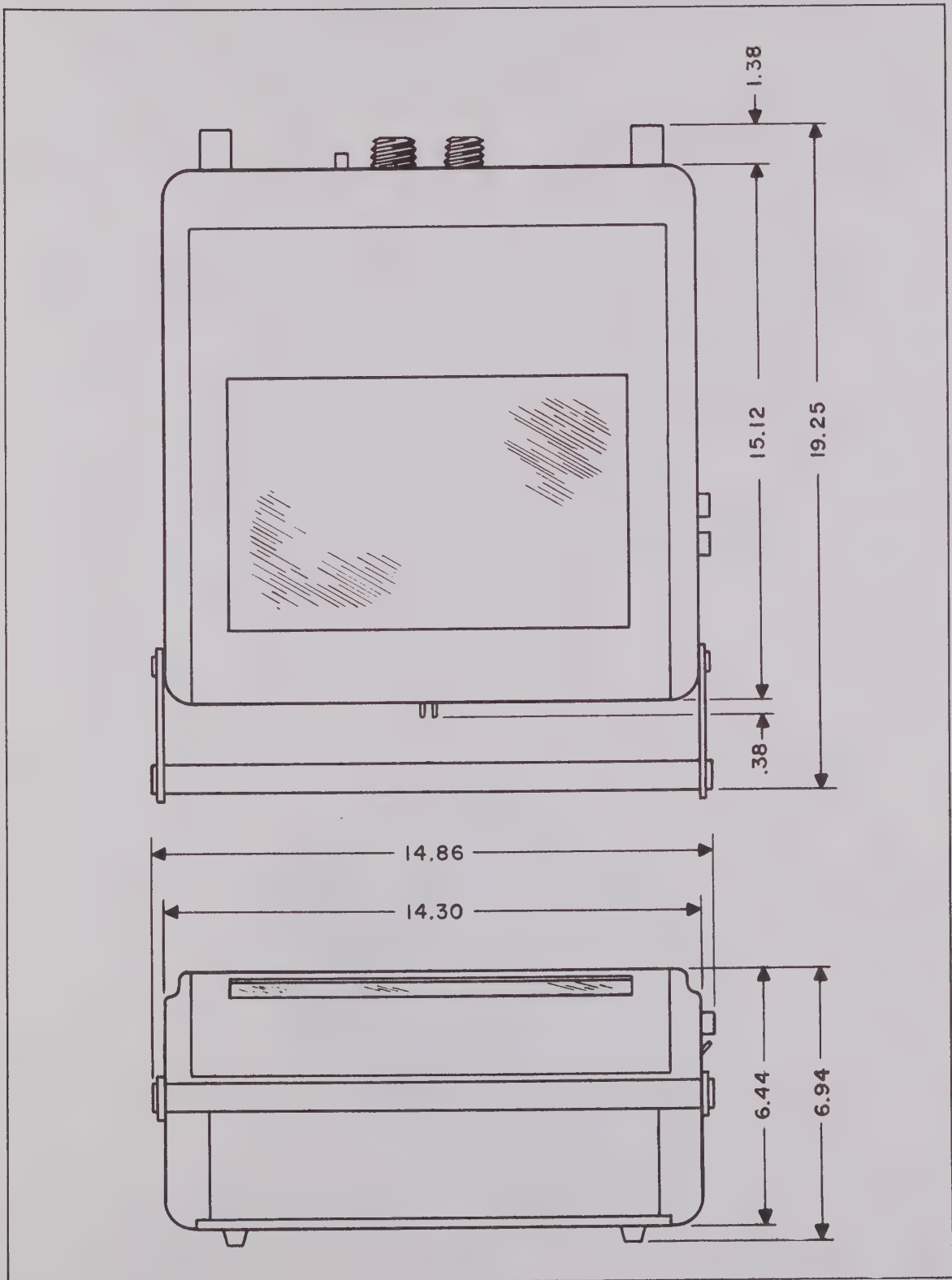


Fig. 1. Dimensional Outline, Brush Oscillograph, Model RD 2361 00

Section II

Operation

PREPARATION FOR USE

a. To Fill Inkwells

To fill inkwells proceed as follows:

1. Remove the rubber stopper and by means of a medicine dropper (or the dropper supplied with the 2 oz bottle of Brush ink) fill the inkwell. Fig. 5.
2. Replace the stopper.
3. Remove and later replace the formed tube in the stopper. To start the ink flowing, empty the medicine dropper and insert it tightly in the small breather hole at the top of the stopper. Press a few times on the bulb until the ink begins to flow. The dropper must be held tightly in the stopper to prevent the ink from squirting.

4. The ink will continue to flow by capillary action. Always keep the pen on the chart paper when not in use as this prevents the ink from drying in the PEN TIP.

It is recommended that both PEN and INK-WELL be removed and thoroughly cleaned, if the oscillograph remains unused for more than three days. It is important to clean the INK-WELL because of possible accumulation of residue in the bottom of the INKWELL which, if allowed to remain, may break free and possibly clog the PEN. Even though in constant use, it is well to clean the INKWELL occasionally for the same reason. For instructions on cleaning PENS and INKWELLS, refer to Section VI - Maintenance.

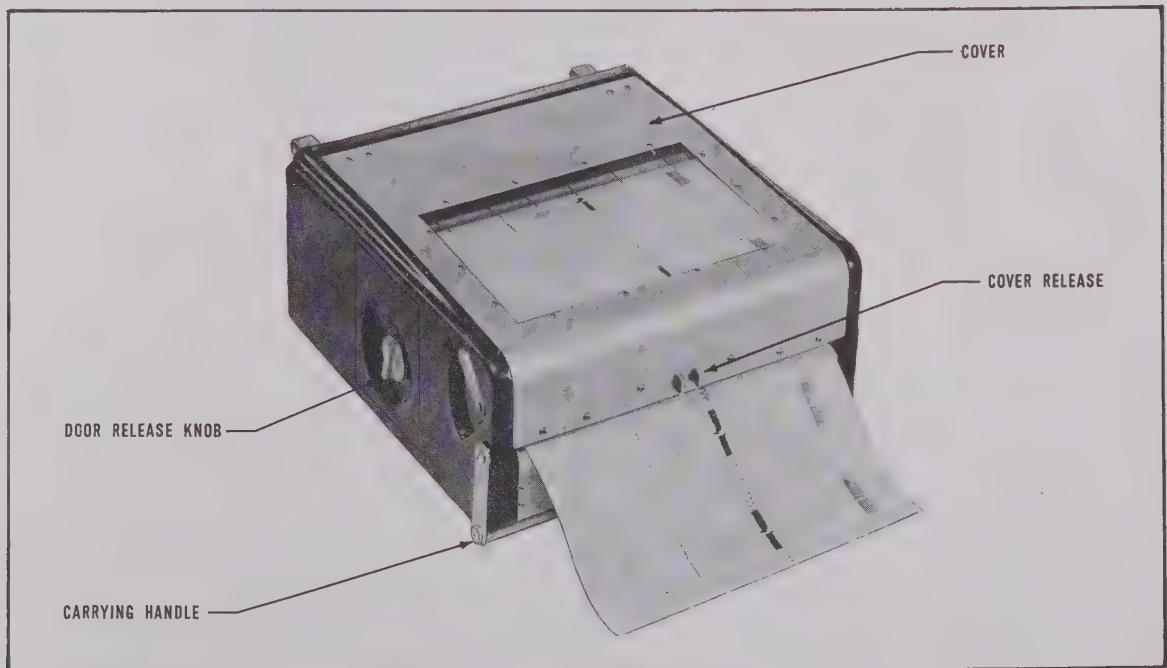


Fig. 2. Brush Portable Six Channel Oscillograph, Model RD 2361 00

b. To Load or Change Chart Paper

To load or change chart paper, proceed as follows:

1. Remove the PAPER SUPPLY DOOR, Fig. 3.
2. Cut the end of the chart paper at an angle of approximately 45° . The point of the chart paper must be on the PAPER SUPPLY DOOR side. This will facilitate threading the chart paper through the oscillograph.
3. Lift the COVER of the oscillograph by means of the COVER RELEASE, Fig. 2.
4. Lift the pens or styli with the PEN LIFTER, Fig. 3.
5. Slip the new supply of chart paper over the PAPER SUPPLY SHAFT as shown.
6. Lead the pointed end of the chart paper over the GUIDE ROD: under the TENSION ROLL: up and over the WRITING BAR, Fig. 4. Care should be exercised not to snag the tips of the pens or styli with the end of the chart paper.
7. Release the tension on the PRESSURE ROLLERS (Figs. 3 and 4) by means of the PRESSURE RELEASE LEVER, Fig. 3.
8. Pull the chart paper over the writing table and DRIVE ROLL, Figs. 3. and 4.
9. Insert the chart paper in the top of the PAPER CHUTE beneath the PRESSURE ROLLERS.

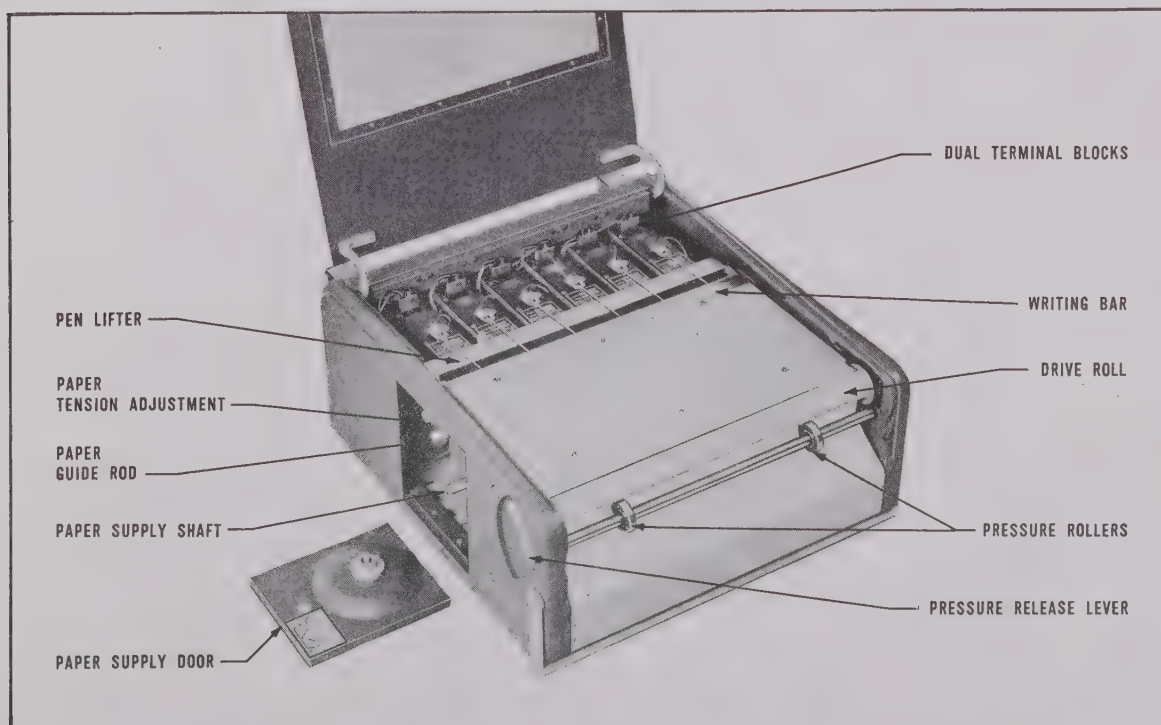


Fig. 3. Brush Portable Six Channel Oscillograph, Model RD 2361 00 with Cover Open

10. Withdraw the chart paper two or three inches from the front of the oscillograph.
11. Release the PRESSURE RELEASE LEVER.
12. Lower the pens or styli onto the chart paper by means of the PEN LIFTER.
13. Close and snap shut the COVER.
14. Replace and fasten the PAPER SUPPLY DOOR. Fit the door snugly. When tightened, the DOOR RELEASE KNOB which is spring loaded, will put the correct amount of pressure on the PAPER SUPPLY roll.
15. Run a short test length of chart paper to determine that it runs in proper alignment. The oscillograph is checked for alignment of the chart paper drive before it leaves the factory.

ment. The oscillograph is checked for alignment of the chart paper drive before it leaves the factory.

NOTE: In the event it is desirable to use four channel chart paper in the six channel portable oscillograph, it may be done by employing the two identical spacer sleeves provided. The spacer sleeves are stored inside the oscillograph, mounted in spring clips. Access to the spacer sleeves is by way of the paper supply door. To use four channel paper, first slip one of two spacer sleeves over the paper supply shaft. Next, slip the roll of four channel onto the paper supply shaft. Finally, slip the second spacer sleeve onto the paper supply shaft.

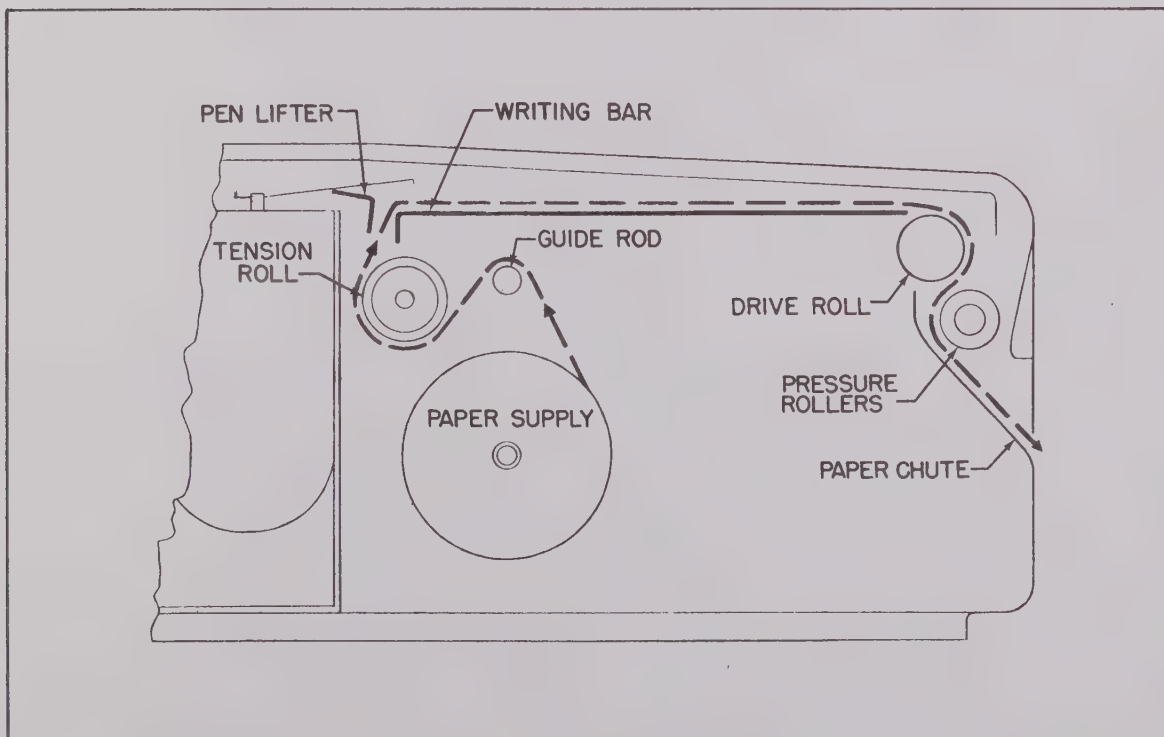


Fig. 4. Paper Loading Diagram

c. To Remove Styli or Pens and Inkwells

If it is desired to write with electric styli on Teledeltos chart paper, it will be necessary to remove the PENS and INKWELLS and replace them with electric styli. Always turn the oscillograph "off" when removing or mounting styli or pens. To make this change proceed as follows:

1. Spread the sides of the PENHOLDER (Fig. 5) with the tips of the Pen Mounting Tool (supplied).
2. Slide the PEN from the PENHOLDER. Avoid snagging the PEN TIP while removing it.
3. While holding the PEN, remove the INKWELL from its holder.
4. Over an expendable surface (old newspapers, etc) remove the CAPILLARY TUBE from the INKWELL. Do NOT remove the CAPILLARY TUBE from the PEN.
5. Clean both PENS and INKWELLS before storing, to prevent the ink from drying in them. For instructions on cleaning PENS and INKWELLS, refer to Section VI - Maintenance.
6. After removing pens, store each one in a separate container (tube, envelope, etc) identified by number (1, 2, 3, etc) with the channel from which it was removed. This eliminates re-lapping the pens after remounting.
7. Remove electric styli in a similar manner to ink pens.

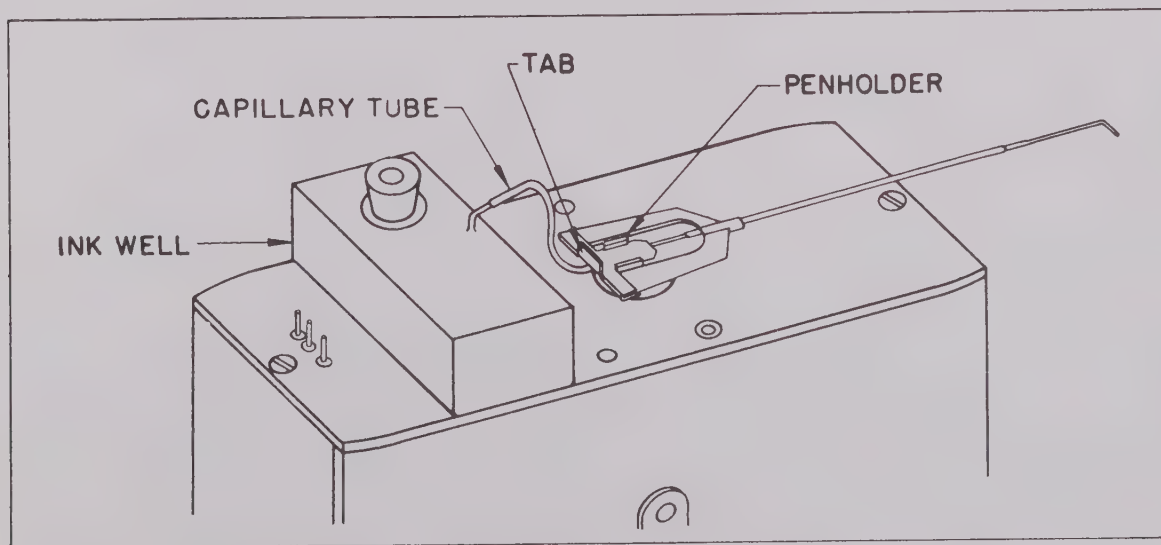


Fig. 5. Diagram of Penmotor and Pen

d. To Mount Pens

Always turn the oscillograph "off" when removing or mounting styli or pens. To mount pens proceed as follows:

1. Grasp the SHANK of the PEN between the thumb and forefinger. Fig. 6.
2. Place the YOKE of the PEN over the PENHOLDER in such a manner that the PENHOLDER will protrude through the YOKE of the PEN. In this position, the TONGUE of the PEN is behind the PENHOLDER.
3. Align the TONGUE of the PEN with the grooves of the PENHOLDER. Figs. 5 and 6.
4. Gently spread the sides of the PEN-
5. With the sides of the PENHOLDER spread, insert the PEN as far as possible. It is important that the PEN be well seated.
6. After removing the Pen Mounting Tool, examine the PEN in the PENHOLDER to determine that the TONGUE is secure and is held in the bottom of the grooves of the PENHOLDER.
7. Lead the CAPILLARY TUBE of the ink PEN to the left of the PENMOTOR.
8. Slip the CAPILLARY TUBE over the metal tube of the INKWELL.
9. Mount the INKWELL in its holder.

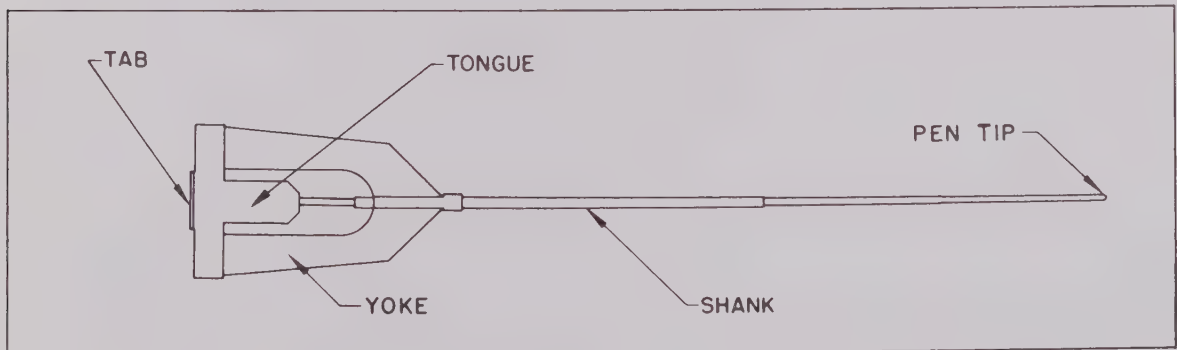


Fig. 6. Diagram of Pen

e. To Mount Styli

Always turn the oscillograph "off" when removing or mounting styli or pens. To mount electric styli, proceed as follows:

1. Repeat steps 1 through 6, above.
2. Plug the lead from the stylus into one side of the DUAL TERMINAL BLOCK above and between adjacent PENMOTORS. Fig. 3. The extreme left and right terminals of the extreme left and right DUAL TERMINAL BLOCKS are to be used exclusively for the LEFT and RIGHT EVENT MARKER stylus leads.

f. To Adjust Pen or Stylus Pressure

When new pens or styli are installed, it is important that the tips of the pens or styli apply .5 to .75 gram pressure on the chart paper. This measurement is critical and must be made very accurately. The reading is taken with the hook of the Gram Gage (Brush Part No. 227418-910) under the PEN or stylus at a point 1/32 inch back of the tip, immediately at the time the tip is lifted from the chart paper. For complete pen pressure information, refer to Section IV - Theory of Operation. If the pen or stylus pressure is unsatisfactory, adjust it as follows:

1. If the pressure is too great, it may be reduced by lifting the PEN tip (while it is in the PENHOLDER) a few times until the proper pressure is achieved. In electric writing, be sure the current is turned OFF as the styli carry a high voltage.
2. If the pressure is too little, the PEN must be removed from the PENHOLDER before the pressure can be increased.
3. After removing the PEN from the PENHOLDER, grasp the TONGUE-TAB in one hand the YOKE in the other.
4. Bend the center of the YOKE upward. This changes the plane of the TONGUE in relation to the plane of the YOKE and produces more pressure on the chart paper when the PEN is remounted.
5. Remount the PEN in its PENHOLDER.
6. Remeasure the PEN pressure. It may be necessary to repeat the above steps.

g. To Align Pens or Styli

1. Be sure all PENS are seated in the PEN-HOLDERS as far as possible.
2. If necessary, the PENS can be backed-out of the PENHOLDER a slight distance by the use of the Pen Mounting Tool supplied with the instrument. Insert the tips of the Pen Mounting Tool in the PENHOLDER. By gently squeezing the Pen Mounting Tool, the sides of the PENHOLDER can be expanded enough to permit backing-out of the PEN TIP so that it will be aligned with the other PEN TIPS. The shortest PEN should always be seated as far as possible in the PENHOLDER.

NOTE: The above information applies equally well to the styli in electric writing.

h. To Lap Pens

When installing new ink pens, it is necessary to lap the pens after installation, in order to write uniformly at all frequencies, and at all chart paper speeds. To do this, connect the oscillograph to an appropriate power source and to an amplifier and an oscillator, as described in the Operating Instructions for the particular amplifier being used, then proceed as follows:

1. Release the tension of the PRESSURE ROLLERS. Fig. 3. This is to keep the chart paper from moving.
2. Lap the PEN TIP by operating the oscillograph at approximately 60 cps, with the strip of abrasive (supplied with the pen) under the PEN TIP. Allow ink to flow

through the PEN to lubricate the PEN TIP during the lapping process.

3. Restore tension on the PRESSURE ROLLERS and test for satisfactory pen trace at various frequencies and at all chart paper speeds. Repeat lapping, if necessary.

It is recommended that both the PEN and INKWELL be removed and thoroughly cleaned

if the oscillograph remains unused for more than three days. It is important to clean the INKWELL because of possible accumulation of sediment in the bottom of the INKWELL, which if allowed to remain may possibly clog the PEN. Even though in constant use, it is well to clean the INKWELL occasionally for the same reason. For instructions on cleaning PENS and INKWELLS, Refer to Section V - Maintenance.



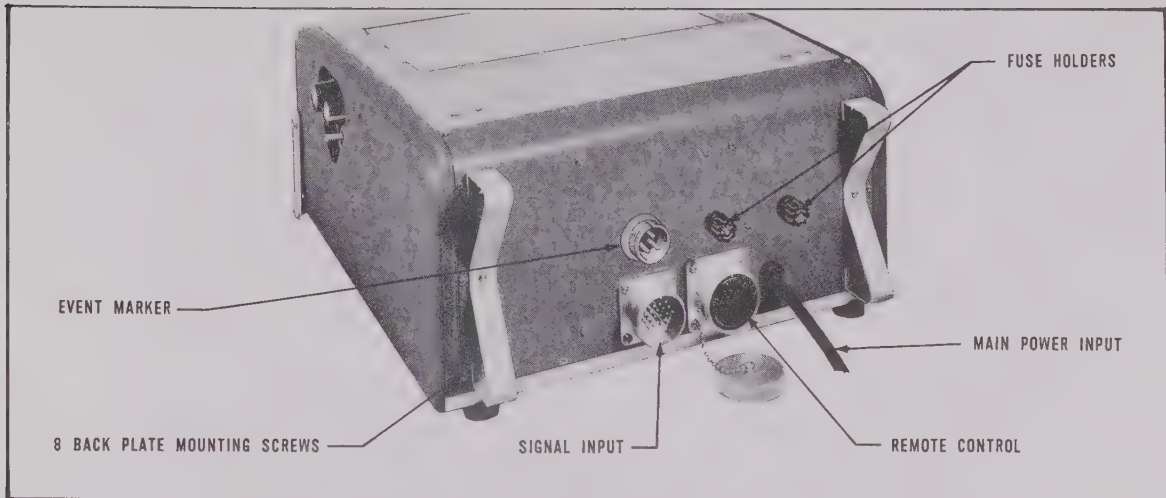


Fig. 7. Rear of Brush Portable Six Channel Oscillograph, Model RD 2361 00

PRELIMINARY OPERATION

a. To Set Up the Instrument

Set up and test the instrument in the following manner:

1. Connect the oscillograph to an appropriate power source (105-125 volts, 60 cps).
2. Turn the SELECTOR SWITCH to the STANDBY position. Fig. 8.
3. Connect the SIGNAL INPUT connector (Fig. 7) with the Junction Box by means of the 25 foot cable supplied.
4. Connect the cables from the amplifiers to the respective connectors on the Junction Box. The connectors on the Junction Box are identified in numerical order corresponding to the individual penmotors.
5. Place the INK-OFF-ELECTRIC SWITCH on the INK position. Fig. 8.

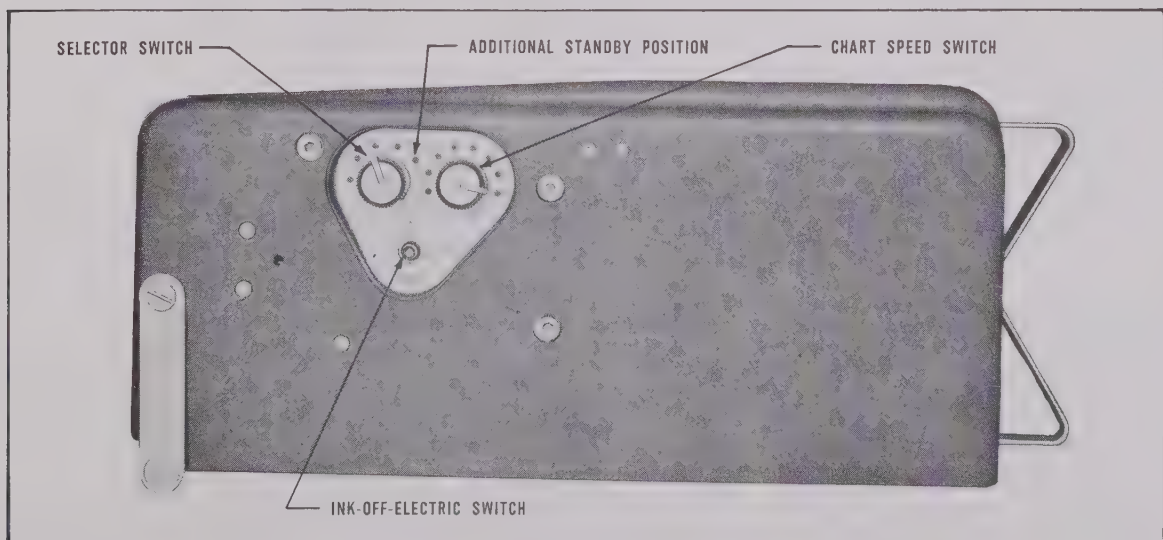


Fig. 8. Right Side of Brush Portable Six Channel Oscillograph, Model RD 2361 00

6. Select the chart paper speed desired by means of the CHART SPEED SWITCH. Fig. 8.
7. Turn the SELECTOR SWITCH to either MM/SEC or CM/HR according to the chart paper speed desired. This switch works in conjunction with the CHART SPEED SWITCH. Fig. 8.
8. Turn the SELECTOR SWITCH to STANDBY to stop the oscillograph, if operating at MM/SEC. If operating at CM/HR turn the SELECTOR SWITCH to the ADDITIONAL STANDBY POSITION to stop the oscillograph. Fig. 8. The use of the ADDITIONAL STANDBY POSITION eliminates the necessity of going through the MM/SEC position in order to stop the oscillograph when operating in the CM/HR position.

The INK-OFF-ELECTRIC SWITCH should be used only to select either ink pen or electric stylus operation and to disconnect all current from the oscillograph. The SELECTOR switch should be used as the operational ON-OFF switch. To use electric styli and electric writing paper it is necessary to use an accessory Remote Control Box. Refer to Section IV - Supplies and Accessories.

b. To Connect Event Markers

To operate the accessory Event Markers it is necessary to solder two leads from switch (customer supplied) to the portion of the connector matching the event marker connector on the back of the oscillograph. Fig. 7. Pin 2 of the connector is in the HOT or common pin while pin 3 completes the circuit to the Right Event Marker and pin 1 completes

the circuit to the Left Event Marker. After soldering and reassembling the male portion of the connector, it is only necessary to connect the cable to the oscillograph.

WARNING: Pins 1 and 3 are connected directly to the main power line, therefore one terminal of each event marker switch is also connected directly to the main power line.

For a complete description of the Event Markers refer to Section IV - Supplies and Accessories.

c. To Connect Remote Control

To control the oscillograph from a remote position, set up the instrument as previously explained and proceed as follows:

If the Combination Remote Control Box, Model RA2403-02, is to be used it is necessary to equip the oscillograph with electric styli and electric writing (Teledeltos) chart paper. If the instrument is not so equipped change the chart paper and change the pens for styli. To do this refer to sections titled "To Load or Change Chart Paper", "To Remove Styli or Pens and Inkwells" and "To Mount Styli".

1. Connect the Remote Control Box, Model RA2403-01, or the Combination Remote Control Box, Model RA2403-02, to the AN connector on the rear of the oscillograph indicated as REMOTE CONTROL in Fig. 7.
2. Place the SELECTOR SWITCH of the Remote Control Box in position marked OFF. Fig. 9.

3. Place the INK-OFF-ELECTRIC switch of the oscillograph in the INK or ELECTRIC position. Fig. 8.
4. Place the SELECTOR SWITCH of the oscillograph on the position marked REM (remote). Fig. 8.
5. For electric writing, place each of the TRACE DENSITY SWITCHES on the combination Remote Control Box in either the HIGH or LOW position. This selection is at the option of the operator. The density of the line desired for each individual channel is a function of and determined by the frequency and the amplitude of the recorded signal.
6. Turn the CHART SPEED SWITCH of the Remote Control Box (Fig. 9) to the desired chart paper speed.

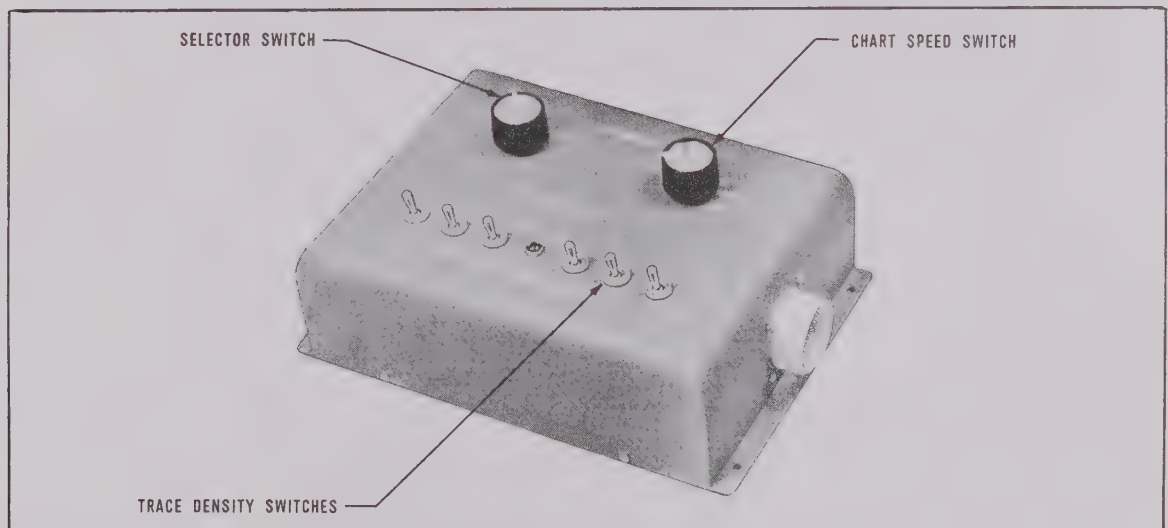


Fig. 9. Remote Control Box with Power Supply for Electric Writing, Model RA 2403-02

7. To start the oscillograph turn the SELECTOR SWITCH of the Remote Control Box to either MM/SEC or to CM/HR as desired.
8. To stop the oscillograph turn the SELECTOR SWITCH of the Remote Control Box to position marked OFF.

d. Operation

Brush oscillographs are designed to operate in conjunction with Brush amplifiers. The fre-

quency compensation of each amplifier may be adjusted to match the penmotor with which it is used. For frequency compensation procedure, refer to the appropriate amplifier Operating Instructions. The circuitry of the amplifier prevents more than 100 volts A C. (peak-to-peak) being applied to the penmotors of the oscillographs. If amplifiers other than Brush amplifiers are used, precautionary measures must be employed to prevent more than this voltage being applied to the penmotors. The performance of Brush oscillographs cannot be guaranteed if used with amplifiers other than Brush amplifiers.

Section III

Supplies

OPERATING SUPPLIES

RA2961-30	Chart Paper, Ink, 6 Channel, 350 feet long
RA2962-20	Chart Paper, Electric, 6 Channel, 235 feet long.
RA2961-30	Red Ink, available in 2 oz., 1 pt and 1 qt containers (ink writing)
RA2962-20	Red Ink, available in 2 oz., 1 pt., and 1 qt. containers (electric writing)
NOTE: Ink is available in other colors on special order.	
125160-501	Pen Cleaning Syringe
227418-910	Gram Gage
126717	Pen Mounting Tool
106000-2	Allen wrench
106000-3	Allen wrench
106000-6	Allen wrench

ACCESSORIES

a. Slow Speed Motor Kit - Model RA2102-30

The Slow Speed Motor Kit is a synchronous motor, mounted within the chassis of oscillograph, Model RA2361-00. The motor is factory installed when purchased with the oscillograph, but may be purchased and installed at a later date, if desired. The Slow Speed Motor is used for special applications where recordings over a long period of time are to be made. This motor, mounted inside the chassis, provides chart paper speeds of 1,

2, 5, 10, 25, 50, 125, and 350 centimeters per hour in addition to the standard speeds in millimeters per second.

b. Event Markers - Left, Model RA2103-31
Right, Model RA2103-32

The Accessory Event Markers are relay powered pen or electric stylus holders. They are internally powered but actuated externally by means of a customer supplied switch. Either or both must be ordered at the time of ordering the oscillograph as they must be factory installed.

Section IV

Theory of Operation

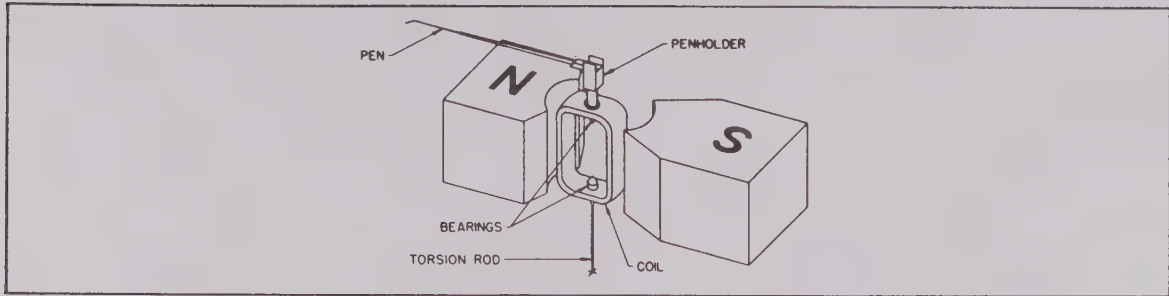


Fig. 10. Simplified Drawing of Penmotor

THEORY OF OPERATION

a. The Penmotor

The Brush Magnetic Penmotor makes use of the familiar D'Arsonval galvanometer type mechanism in which the coil is used to deflect a pen instead of the conventional mirror.

The penmotor, Figure 10, consists of a coil supported by sapphire jeweled bearings and mounted in the magnetic field of an Alnico V structure. A signal current passing through the coil causes, by motor action, a deflection of the coil about its axis; the deflection in turn causes the movement of the writing pen which is affixed to the coil.

The Brushpenmotor differs from the classical galvanometer with its delicate hair springs, in that it makes use of a heavy torsion spring which maintains the zero position of the coil, and also serves the function of holding the coil in its upper bearing by supplying a downward force.

The resonant frequency of the penmotor is established by the stiffness of the torsion spring and the mass of the combined coil and pen assembly. In the subject penmotor the resonance is at a relatively high frequency (about 47 cycles) and the system has the necessary stiffness to maintain a high degree of linearity in the presence of the variable effects of pen tip friction on the writing medium.

The flatness of frequency response with constant voltage input is determined by a number of factors which must be in the proper relationship to obtain the required damping. The mass of the moving system, the stiffness of the torsion spring, the magnetic flux, and the relationship of coil turns and resistance must all be carefully related in the penmotor design to obtain critical damping.

When a number of penmotors are mounted in an oscillograph, individual penmotors have their effective flux increased by adjacent penmotors. The outside penmotors then have less flux than the in-between penmotors; this of course affects the sensitivity of the penmotors. To equalize their sensitivity series resistors are used with the in-between penmotors.

The penmotors, when driven by the Brush RD series amplifiers, operate at about 60 per cent of critical damping which provides the optimum balance between transient response and frequency response. Without compensation the response is flat to about 30 cycles. The Brush RD series amplifiers, in addition to providing optimum damping characteristics, include compensating networks to off-set the decreasing sensitivity of the penmotor above 30 cycles. The compensation adjustment thus can provide a flat response from D.C. to 100 cps based on a 10 millimeter chart amplitude.

Theory of Operation

The maximum permissible excursion of the pen is limited at high frequencies by the large forces and velocities inherent in such a system. For example, at 100 cps at the specified maximum amplitude of 10 mm (peak-to-peak), the pen tip velocity is about 3000 mm/sec. Under these conditions the acceleration experienced by the pen tip is about 200 times the acceleration of gravity.

b. Pen Pressure

For optimum writing from D.C. to 100 cps, the pen tip pressure should be adjusted to $5/8$ gram, $\pm 1/8$ gram. This pressure is light enough to produce accurate recordings in the low frequency range from D.C. to 10 cps, and is high enough to produce very legible writing from 10 to 100 cps. If flat response $\pm 1/2$ chart line (mm) is desired from D.C. to 10 cps at 40 chart lines (mm) peak-to-peak, it is recommended that $3/8$ gram pen pressure be used. This pressure produces minimum friction and results in improved accuracy of response from D.C. to 10 cps. However, at higher frequencies it is not sufficient pen pressure to prevent hit-skip writing.

If the majority of the recordings are to be made in the range from 10 to 100 cps, a pen pressure of $1-1/4$ grams is recommended. This pressure will write from D.C. to 10 cps, but the high friction involved reduces the linearity of recordings made in this range.

c. Use of Oscillograph With Other Than Brush Amplifiers

In using this oscillograph with any input other than from Brush amplifiers, precautions must

be taken not to exceed a current of 25 milliamperes or 35 volts D.C., or 100 volts A.C. peak-to-peak.

d. Ink Versus Electric Writing

There are individual advantages to both ink and electric writing. The method of writing is determined by the type of operation.

Some of the advantages of ink writing are as follows:

1. Better linearity
2. Trace density is uniform
3. Ink chart is economical
4. Good reproductions by photography or most of the many reproduction systems using heat or light such as blueprinting.

Some of the advantages of electric writing are as follows:

1. Unattended operation. This feature is particularly valuable on protracted, unattended operations or where intermittent, unattended operations are necessary.
2. Recording at sub-freezing ambient temperatures.

e. General Precautions

In general it is well to observe the following precautions when using oscillographs:

Theory of Operation

1. Keep watches, chronometers and similar instruments away from the oscillograph as their movements may become magnetized.
2. Avoid dropping the oscillograph as it may affect the magnetism of the penmotor.
3. Avoid getting dirt, dust, metal filings, etc., in the penmotor as they may affect the satisfactory operation of the oscillograph.
4. If the penmotor becomes damaged in any fashion, do not attempt to repair it as special fixtures are necessary for coil alignment and special equipment is required for proper magnetization. Remove it from the oscillograph and send it to the factory for repair.
5. In aligning a penmotor when replacing it, do not tap or hammer it as the penmotor may lose some of its magnetism.

Section V

Maintenance

MAINTENANCE

a. Lubrication

The only lubrication necessary is an occasional application of a good quality, light silicone grease to the fiber gear between the drive motor and the transmission. The writing table must be removed to gain access to this gear. The balance of the instrument has been "life-time" lubricated.

b. To Clean Pens and Inkwells

Clogged pens can be cleaned with the Brush Pen Syringe (Part No. 125160-501). The syringe is spring loaded; when the plunger of the syringe is depressed and released, it will return to its original position. To clean a clogged pen, proceed as follows:

1. Remove the PEN and INKWELL from the oscillograph. Fig. 5.
2. Remove the CAPILLARY TUBE from the INKWELL. Do not remove the CAPILLARY TUBE from the PEN.
3. With the plunger of the syringe depressed, insert the syringe needle into the end of the CAPILLARY TUBE. Continue to hold the plunger depressed.
4. Insert the tip of the PEN (Fig. 6) into a tumbler of room temperature water and release the plunger. The vacuum thus created will tend to draw water from the outside of the PEN into the syringe.

WARNING: It is important to follow this procedure in using the syringe, since the tip of the pen is tapered on the inside, and water must come from the outside of the pen tip. Water passing through the pen in the wrong direction will cause further clogging in the pen.

The above procedure may be repeated until water enters the PEN or syringe, when the syringe must be removed from the CAPILLARY TUBE and emptied; the cleaning procedure may then be repeated. If this procedure does not clear the PEN, allow PEN to soak overnight in room temperature water and repeat cleaning procedure.

The INKWELLS (Fig. 5) should be removed from the oscillograph and cleaned periodically to dispose of sediment which collects in the INKWELL. The INKWELLS may be soaked in room temperature water and rinsed thoroughly. The siphon tube in the INKWELL may be rinsed by means of the Syringe.

c. To Measure Chart Paper Tension

The oscillograph leaves the factory with the chart paper tension adjusted for ink writing (1-1/2 to 2 pounds) unless otherwise specified. Electric writing requires a chart paper tension to 2 to 2-1/2 pounds. Incorrect chart paper tension results in the paper not remaining flat on the writing table (tension too loose) or a squeaking sound as the chart paper is pulled over the WRITING BAR (tension too tight). Tension that is too tight will result in slowing the speed of the chart paper and a consequent error in the time factor of the graph. To measure the chart paper tension, proceed as follows:

1. Remove the paper from the PAPER CHUTE at the front of the oscillograph. Allow the paper to be free on the writing table.
2. Fasten one end of a strip of cellophane tape around the hook of a spring scale. (Customer supplied).

3. Fasten the other end of the cellophane tape firmly along the center line of the chart paper.
4. Pull the chart paper by means of the spring scale along the top of the writing table. As the chart paper unwinds from the SUPPLY ROLL, the scale should read between 1-1/2 and 2 pounds for ink writing chart paper and between 2 and 2-1/2 pounds for electric writing paper. These amounts will increase slightly with a partially used SUPPLY ROLL of chart paper.

d. To Adjust Chart Paper Tension

To adjust the chart paper tension, proceed as follows:

1. Remove the PAPER SUPPLY DOOR. Fig. 3
2. With a screwdriver hold the slot of the PAPER TENSION ADJUSTMENT to prevent its turning. Fig. 3.
3. Loosen the locknut of the PAPER TENSION ADJUSTMENT.
4. Turn the screwdriver slot in the proper direction to attain the tension desired. (Turning in a clockwise direction decreases the tension while turning in a counterclockwise direction increases the tension.)
5. Hold the screwdriver slot to prevent its turning and tighten the locknut securely. This is important.
6. Replace the PAPER SUPPLY DOOR.
7. Re-measure the chart paper tension and re-adjust, if necessary.

e. To Align Penmotors

Penmotors are factory aligned. The arc struck by the pen must match the printed arc on the chart paper within $\pm .005$ inches measured at full deflection, to meet factory standards. This is a function of the lateral adjustment of the penmotor. The pen tips must be within $\pm 1/64$ inches at a line perpendicular to the edge of the chart paper. This is a function of the forward and backward adjustment of the penmotor.

If it is necessary to re-align one or more penmotors, proceed as follows:

1. Run the oscillograph for a few minutes to center the chart paper.
2. Turn OFF the oscillograph.
3. Securely block-up the instrument on a solid work surface, sufficiently high to allow working space beneath. (Usually two 2x4/s placed on edge under the front and under the back of the instrument are adequate.)
4. While keeping the instrument blocked up, loosen very slightly, the PENMOTOR POSITIONING SCREWS of the particular penmotor to be adjusted. Fig. 10. Usually 1/4 of a full turn is sufficient.
5. Grasp the penmotor in both hands and move slightly in the proper direction. Do not tap the penmotor with a hammer or any tool as this may affect the magnetism.
6. Test the alignment by gently moving the pens in succession, across the chart paper. The chart paper must be taut on the writing surface.

7. Tighten securely the PENMOTOR POSITIONING SCREWS previously loosened.
8. Re-test as in step 5 above. If necessary repeat above alignment procedure.

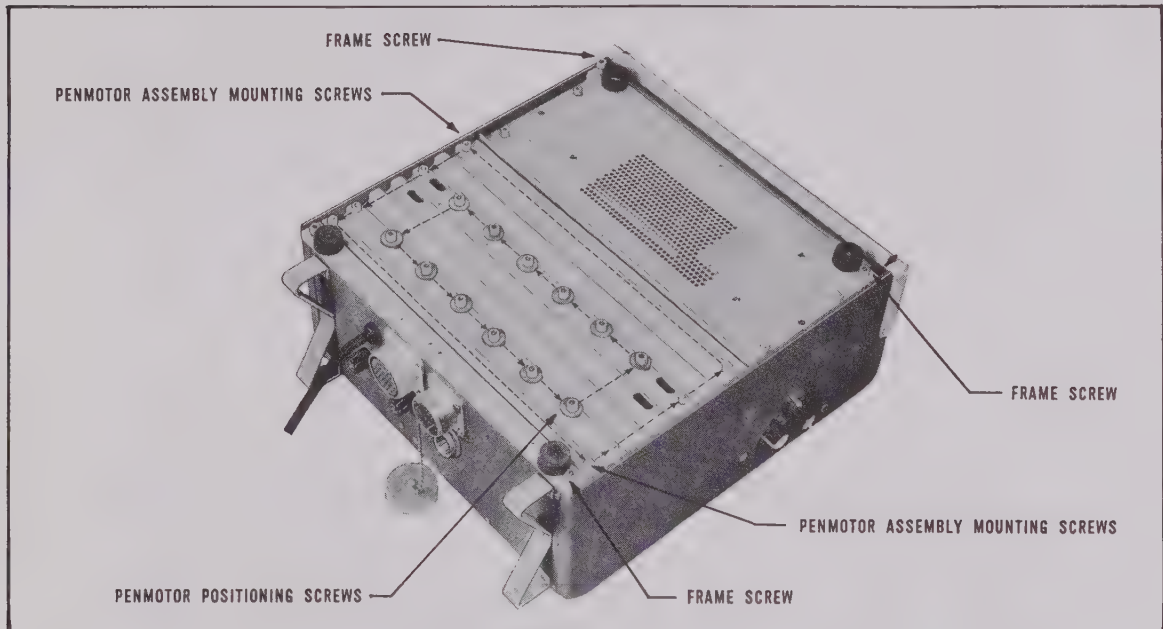


Fig. 11. Bottom of Brush Portable Six Channel Oscillograph, Model RD 2361 00

TROUBLESHOOTING

The chart below lists symptoms and probable causes of improper operation of the oscillograph, or failure of the oscillograph, as well as probable remedies for unsatisfactory operation.

The conditions described in the chart are for the Portable Six Channel Oscillograph Model RD2361-00, operating from 105-125 volts, 60 cps power source. Procedures suggested in the Remedy column may be performed by operating personnel.

SYMPTOM	CAUSE	REMEDY
1. Ink pen writes intermittently.	a. Incorrect pen pressure b. Pen tip not fully in contact with paper c. Pen improperly seated in penholder slots	a. Refer to Section "To Adjust Pen or Stylus Pressure." b. Refer to Section "To Lap Pens." c. Re-seat pen properly
2. Ink pen will not write.	a. Lack of ink b. Pen not primed c. Pen clogged	a. Fill inkwell b. Prime pen. Refer to Section "To Fill Inkwells." c. Refer to Section "To Clean Pens and Inkwells."
3. Electric stylus writes intermittently or not at all.	a. Excess carbon deposits on stylus b. Incorrect stylus pressure. c. Defective flexible lead to stylus d. TRACE DENSITY switch improperly adjusted e. Defective rectifier tube f. Filter capacitor shorted	a. Turn INK-OFF-ELECTRIC switch OFF and clean stylus b. Refer to Section "To Adjust Pen or Stylus Pressure." c. Replace stylus d. Adjust TRACE DENSITY switch for optimum writing. e. Replace tube f. Replace capacitor

Maintenance

SYMPTOM	CAUSE	REMEDY
4. Penmotor inoperative	a. Lack of proper signal source b. Defective signal cable c. Open penmotor coil d. Defective relay	a. Connect to proper signal b. Replace or repair cable c. Replace penmotor d. Replace relay
5. Chart paper drive will not operate	a. INK-OFF-ELECTRIC switch not turned ON b. SELECTOR switch on STANDBY c. Fuse open d. Lack of power at source e. Defective power cable f. Defective motor starting capacitor g. Defect in transmission; motor is running h. Drive belt broken i. PRESSURE ROLLERS not in tension j. Defective relay k. Defective drive motor	a. Turn INK-OFF-ELECTRIC switch ON b. Turn SELECTOR Switch c. Replace fuse d. Connect to proper power source e. Repair or replace power cable f. Replace capacitor g. Return transmission to factory for repairs h. Replace drive belt i. Restore tension by means of PRESSURE RELEASE LEVER j. Replace relay k. Replace motor
6. Chart paper speed is not as indicated by CHART SPEED switch or does not change properly as CHART SPEED switch is changed.	a. Defective transmission b. Defective contacts on CHART SPEED switch	a. Return transmission to factory for repair b. Repair or replace switch

Maintenance

SYMPTOM	CAUSE	REMEDY
6. (continued)	c. Defective 90 volt D.C. rectifier d. Improper paper tension	c. Replace rectifier d. Refer to section "To Adjust Chart Paper Tension."
7. Chart paper speed is erratic	a. Erratic transmission b. Variation in frequency of power input	b. Return transmission factory for repair b. Connect to a power line of stable frequency
8. Chart paper drifts	a. Chart paper improperly installed	a. Refer to "To Load or Change Chart Paper."
9. Excessive paper surge when shifting chart speed	a. Defective resistor or capacitor in paper surge suppressor	a. Replace defective component
10. Event marker inoperative	a. Improper wiring of keying circuit b. Relay defective c. Open coil on event marker	a. Refer to Section "To Connect Event Markers." b. Replace relay c. Replace event marker
11. Operation of event marker causing transients in amplifier signal circuits	a. Defective surge suppressor across event marker	a. Replace surge suppressor
12. Arc of pen trace does not match arcs printed on chart paper	a. Improper loading of chart paper b. Improper mounting of individual penmotor	a. Refer to Section "To Load or Change Chart Paper." b. Refer to Section "To Align Penmotors."

Parts Identification

EXPLODED VIEW PARTS LIST

It is recommended that, for major servicing or repairs, the instrument be returned to the factory service stations where facilities are available to restore it to its original condition. In the event that this is impractical or the repair is of a minor nature, the following parts lists and their accompanying exploded views are designed to assist in servicing and repairing. In order to assure prompt and satisfactory delivery of replacement parts, it is very necessary that you include the following information with your order:

1. The name and serial number of the instrument for which the parts are to be used. For example,
"Portable Six-Channel Oscilloscope,
Model RD 2361 00, Serial No. 123".
2. The following specific information on the desired parts:
Brush Part No.
Description
Value (electrical)

NOTE: Do not use the ITEM No. or the SYMBOL No. for identifying desired parts on your order.

Model RD 2361 00

ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER OSCILLOGRAPH
1	Cover Latch Handle	119449	2
2	Paper Chute	219579	1
3	Paper Cutter	119567	1
4	Strip	219623	1
5	Latch Rod	119566	2
6	Spring	111728	1
7	Clamp	119442	2
8	Clamp	119441	1
9	Cover	419625	1
10	Window	319624	1
11	Left Hinge	119473	1
12	Right Hinge	119474	1
13	Screw	119524	2
14	Handle	219588-501	1
15	Spacing Bar	219583	1
16	Terminal Strip	100184-4	1
17	Bumper	120903-204	4
18	Shoe	126889	2
19	Spring	126890	2
20	Pin	4-217274-809	2
20A	Pin	2-217274-812	2
21	Pressure Roll Release Lever	120357	1
22	Washer	120116	1
23	Bushing	119475	2
24	Shim	120411	1
25	Pressure Roll Shaft	219582	1
26	Collar	120059	1
27	Bearing	125217	3
28	Retaining Ring	104307-2	6
29	Bearing	1-210761-1	2
30	Flat Compression Spring	111360-3	1

Parts Identification

Model RD 2361 00 (Cont'd)

ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER OSCILLOGRAPH
31	Drive Roll	120022-501	1
32	Drive Belt	117495	1
33	Retaining Spring	104644-2	1
34	Bearing	119438	1
35	Clip	112844-8	2
36	Four Channel Spacer	231159	2
37	Drive Motor	319627	1
38	Brace	124672	1
39	Plate	244836	1
40	Two Channel Spacer	120266	1
41	Transmission Spacer	119457	2
42	Transmission Gear	119472	1
43	Motor Gear	119934-501	1
44	Transmission	216972-501	1
45	Transmission Pulley	125406	1
46	Spacer	119482	1
47	Capacitor Strap	124120	1
48	Capacitor	20-120142-405	1
49	Bottom Cover Plate	419584	1
50	Paper Insulator	124087	1
51	Rotary Switch	120477	1
52	Switch Protector	120558	1
53	Rotary Switch	117999	1
54	Knob	226343	2
55	Plate	126475	1
56	Toggle Switch	110111	1
57	Writing Table Support Bar	219572	1
58	Brace	119462	1
59	Screw	119456	1
60	Washer	111622	1
61	Door	226527	1
62	Spacer	119483	1
63	Spring	120189	1
64	Plunger	119565	1
65	Holder	119450	1
66	Rod	119569	1
67	Spacer	111732	1
68	Rod	119570	1
69	Mounting Plate	119658-501	1
70	Spring Washer	119486	1
71	Washer	119464	1
72	Writing Bar	219581	1
73	Pen Lifter	119587-501	1
74	Tension Roller	219610-501	1
75	Tension Roller Brake	119440	1
76	Tension Roller Support Rod	119571	1
77	Spring Pin	2-217274-409	2
78	Tension Roller Spring	119461	1
79	Left Side Plate	426514	1
80	Right Side Plate	426515	1
81	Pin	4-217274-807	2
82	Writing Table	219573	1
83	Pen for Ink Writing (Standard)	RA 2821 31	6
83	Pen for Ink Writing (Fine Line)	RA 2811 30	0
83	Stylus for Electric Writing (Standard)	RA 2822 30	0

Parts Identification

Model RD 2361 00 (Cont'd)

ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER OSCILLOGRAPH
84	Ink Tubing (3 Ft.)	126270	0
85	Overflow Tube	116962	6
86	Stopper	126049	6
87	Ink Feeding Tube	126050	6
88	Inkwell	226051	6
89	Penmotor Connector	126001-1	6
90	Penmotor Mounting Bracket	319504	6
91	Penmotor		
	Channels 1, 6	425939-501-123	2
	Channels 2, 3, 4, 5	425939-501-108	4
92	Penmotor Mounting Plate	419585	1
93	Spacing Bar	219583	1
94	Chassis	426576	1
95	Bracket	226578	1
96	Electric Writing Connector	110903	4
97	Cable	126295-1	1
98	Strain Relief	108572-11	1
99	Foot	119446	2
100	Capacitor Bracket	119439	1
101	Relay	5-110243-7	1
102	Retaining Clip	113529-4	1
103	Capacitor	100-117682-106	1
104	Terminal Strip	105982-2	1
105	Fuse	116198-6	1
106	Bracket	126557-501	1
107	Resistor	5-115559-473	1
108	Rectifier	111031	1
109	Fuse	116198-13	1
110	Fuse Holder	119365	2
111	Suppressor	(Part of 112)	1
112	Relay	122214	1
113	Connector	120408	1
114	Button	113294-71	1
115	Connector	121355	1
116	Terminal Board	119513-501	1
117	Resistor	5-115557-152	6
118	Resistor	5-115558-151	2
119	Resistor	5-115558-181	2
120	Cap	121059-28	1
121	Connector	126387-1	1



Parts Identification

Models RA 2103 31 and RA 2103 32

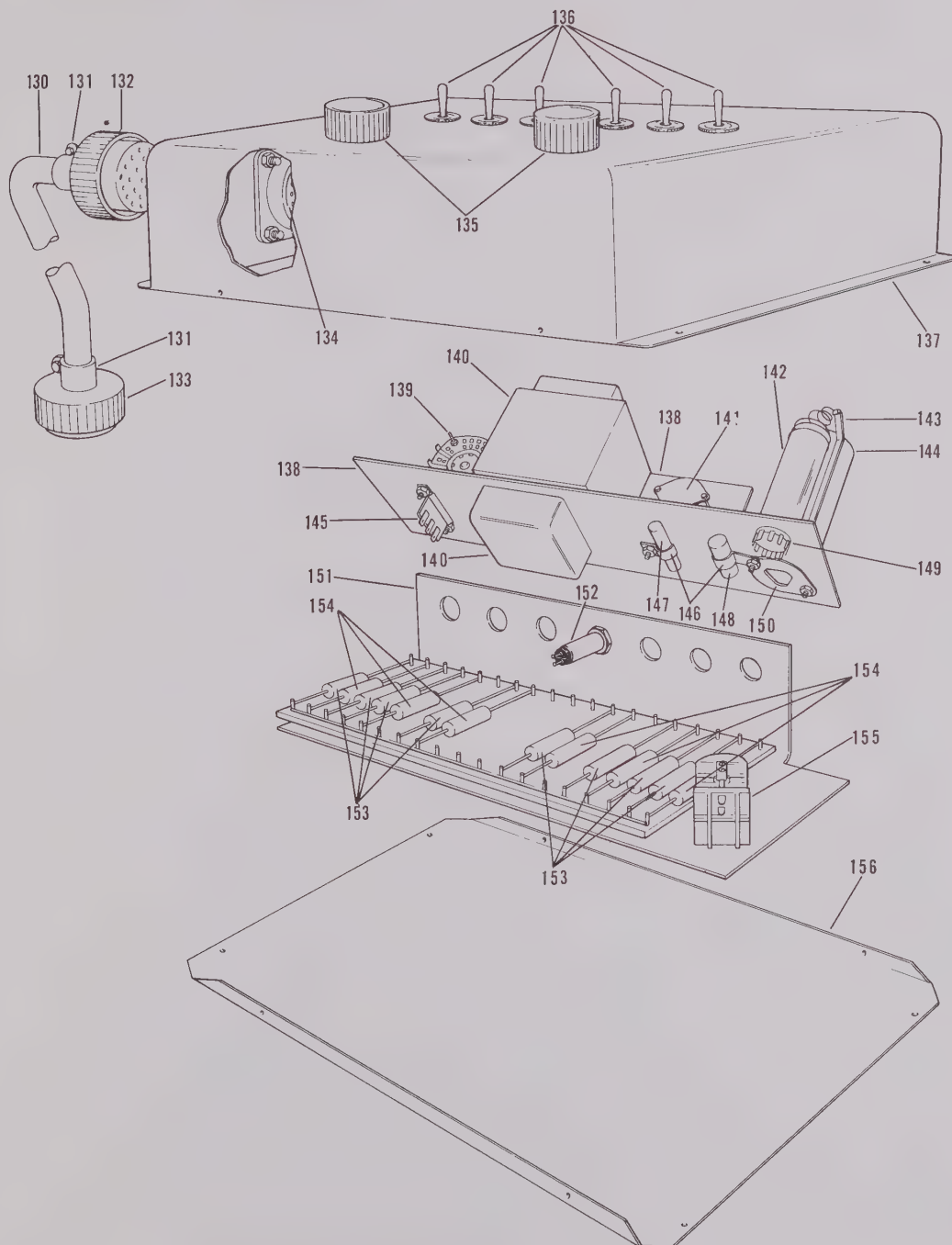
ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER EVENT MARKER	
			RA 2103 31	RA 2103 32
160	Pen for Ink Writing	RA 2871 30	1	1
160	Pen for Electric Writing	RA 2872 30	0	0
161	Overflow Tube	116962	1	1
162	Stopper	6097	1	1
163	Inkwell	108621-PL1	1	1
164	Inkwell Holder	102078	1	1
165	Relay, Penholder, and Suppressor	126167-501	1	0
165	Relay, Penholder, and Suppressor	126257-501	0	1
166	Bracket	326614	1	1
167	Spacer	119776	1	1
168	Connector	126387-1	1	1
169	Connector	126460-1	1	1

Model RA 2102 30

ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER MOTOR	
170	Motor	122037	1	
171	Mounting Plate	120253	1	
172	Gear	119510-501	1	
173	Coupling Clutch	119443	1	

Models RA 2403 01 and RA 2403 02

ITEM NO.	DESCRIPTION	BRUSH PART NO.	QUANTITY PER CONTROL BOX	
			RA 2403 01	RA 2403 02
130	Cable	120689	1	1
131	Cable Clamp	111054-116	2	2
132	Connector	120410	1	1
133	Connector	120409	1	1
134	Connector	120407	1	1
135	Knob	226343	2	0
135	Knob	226344	0	2
136	Toggle Switch	121068	0	6
137	Cover	326807-910	1	0
137	Cover	326771-910	0	1
138	Chassis, Power Supply	319558	0	1
139	Rotary Switch	117999	1	1
140	Transformer	113128	0	1
141	Rotary Switch	120406	1	1
142	Tube	109686	0	1
143	Tube Holder	109680-2	0	1
144	Capacitor	117717-156	0	1
145	Terminal Strip	100184-1	0	1
146	Clamp	124804-3	0	2
147	Resistor	5-118180-503	0	1
148	Resistor	5-119370-251	0	1
149	Tube Socket	118948-103	0	1
150	Capacitor Mounting Bracket	110188	0	1
151	Chassis	319562	0	1
152	Lamp	126621	0	1
153	Resistor	5-115559-154	0	8
154	Resistor	5-115559-104	0	6
155	Relay	9-110243-2	0	1
156	Bottom Cover	218014	1	0
156	Bottom Cover	318017	0	1

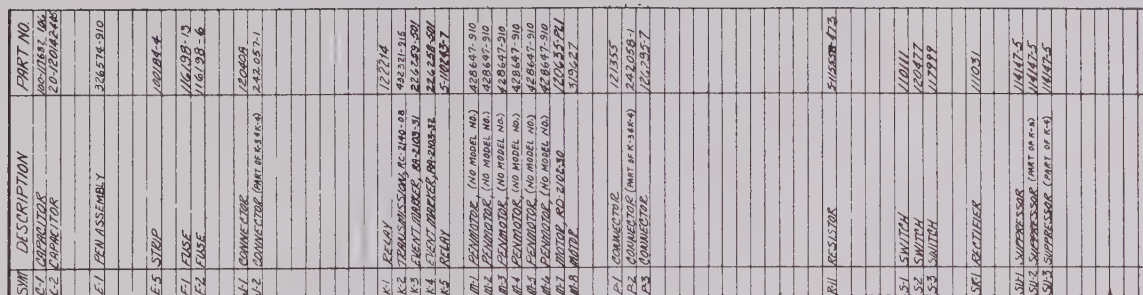


Parts Identification

SCHEMATIC PARTS LIST

Model RD 2361 00

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
C-1	Capacitor, Electrolytic	10 mfd, 450V	100-117682-106
C-2	Capacitor		Part of M-7
C-3	Capacitor, Paper	4 mfd, $\pm 20\%$, 220V	20-120142-405
F-1	Fuse	Type 3AG, "Slo-Blow" 3A, 125V	116198-13
F-2	Fuse	Type 3AG, "Slo-Blow" $\frac{1}{4}$ A, 125V	116198-6
J-1	Connector, Receptacle, Female, 35 Pin	AN Type—AN3102A-28-15S	120408
J-2	Connector, Female, 3 Pin		126001-1
J-3	Connector, Female, 3 Pin		126001-1
J-4	Connector, Female, 3 Pin		126001-1
J-5	Connector, Female, 3 Pin		126001-1
J-6	Connector, Female, 3 Pin		126001-1
J-7	Connector, Female, 3 Pin		126001-1
J-8	Connector, Female, 2 Pin		110903
J-9	Connector, Female, 2 Pin		110903
J-10	Connector, Female, 2 Pin		110903
J-11	Connector, Female, 2 Pin		110903
J-12	Connector, Receptacle, Male, 24 Pin	AN Type—AN3102A-24-28PW	121355
J-13	Connector, Receptacle, Male, 3 Pin		126387-1
K-1	Relay	DPST (NO)	5-110243-7
K-2	Transmission		219672-501
K-3	Relay	6PDT	122214
K-4	Relay, Marker Coil (Includes Suppressor)	(Part of RA 2103 32, Right Event Marker)	116832
K-5	Relay, Marker Coil (Includes Suppressor)	(Part of RA 2103 31, Left Event Marker)	116832
M-1	Penmotor		425939-501-123
M-2	Penmotor		425939-501-108
M-3	Penmotor		425939-501-108
M-4	Penmotor		425939-501-108
M-5	Penmotor		425939-501-108
M-6	Penmotor		425939-501-123
M-7	Motor, Slow Speed	(Part of RA 2102 30, Slow Speed Kit)	122037
M-8	Motor, Fast Speed		319627
P-1	Cable, Power Input		126295-7
	Power Cable Adapter		126294
R-1	Resistor, Composition	47K, $\pm 5\%$, 1W	5-115558-473
R-2	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
R-3	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
R-5	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
R-7	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
R-9	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
R-11	Resistor, Composition	1.5K, $\pm 5\%$, $\frac{1}{2}$ W	5-115557-152
S-1	Switch, Toggle	S.P.D.T.	110111
S-2	Switch, Rotary		120477
S-3	Switch, Rotary		117999
SR-1	Rectifier		111031
	Junction Box		423932-501
	Junction Box C-1		218216-501



Parts Identification

SCHEMATIC PARTS LIST

Model RA 2403 01

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
J-1	Connector, Receptacle, Male, 35 Pin	AN Type—AN3102A-28-15P	120407
S-1	Switch, Rotary		120406
S-2	Switch, Rotary		117999

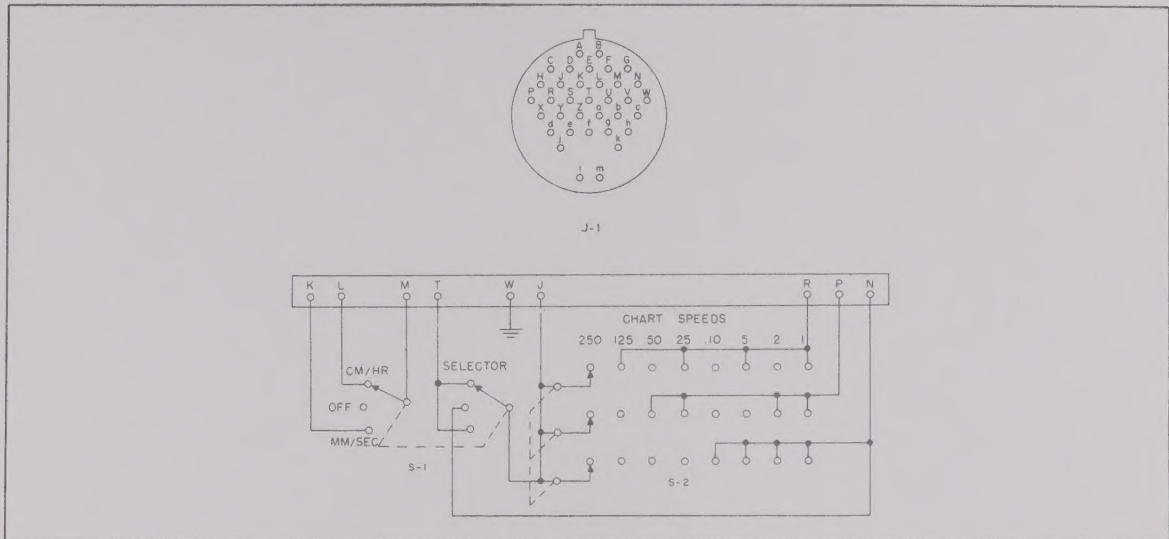
Model RA 2403 02

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
C-1	Capacitor, Electrolytic (½ Dual Section)	15 mfd, 450V	117717-156
C-2	Capacitor, Electrolytic (½ Dual Section)	15 mfd, 450V	Part of C-1
J-1	Connector, Receptacle, Male 35 Pin	AN Type—AN3102A-28-15P	120407
K-1	Relay	SPST (NO)	9-110243-2
NE-1	Lamp		126621
R-1	Resistor, Wire Wound	250 ohms, $\pm 5\%$, 5W	103746-13
R-2	Resistor, Wire Wound	50 K, $\pm 5\%$, 10W	103808-4
R-3	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-4	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-5	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-6	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-7	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-8	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-9	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-10	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-11	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-12	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-13	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-14	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
R-15	Resistor, Composition	100 K, $\pm 10\%$, 2W	10-115559-104
R-16	Resistor, Composition	150 K, $\pm 10\%$, 2W	10-115559-154
S-1	Switch, Rotary		120406
S-2	Switch, Rotary		117999
S-3	Switch, Toggle	SPST	100658
S-4	Switch, Toggle	SPST	100658
S-5	Switch, Toggle	SPST	100658
S-6	Switch, Toggle	SPST	100658
S-7	Switch, Toggle	SPST	100658
S-8	Switch, Toggle	SPST	100658
T-1	Transformer		113128
V-1	Tube, Electron	6X4	109686

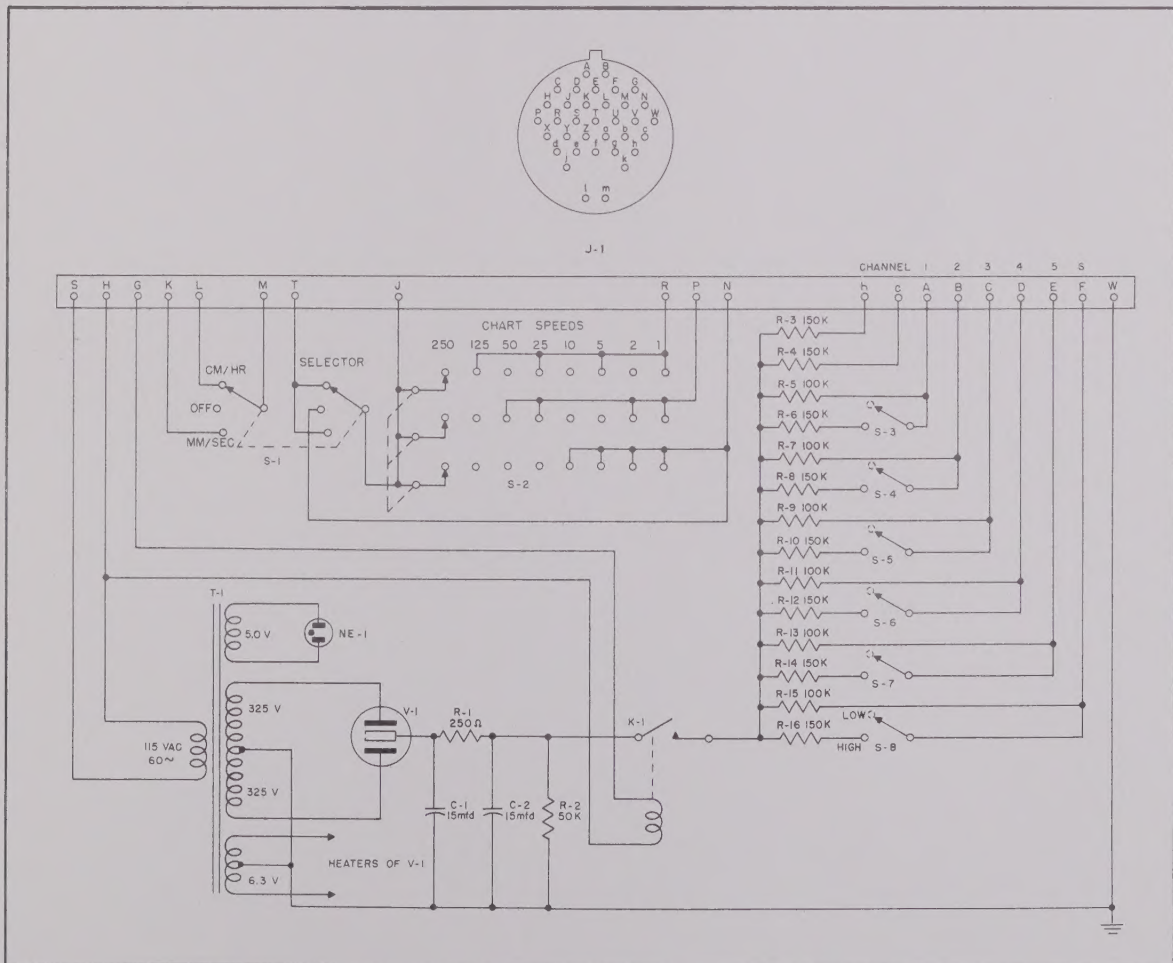
Parts Identification

SCHEMATIC DIAGRAM

Model RA 2403 01



Model RA 2403 02



MP MASTER



MA34684

BRUSH INSTRUMENTS DIVISION

37TH AND PERKINS / CLEVELAND, OHIO 44114 / AREA CODE 216-361-3315

CLEVITE
CORPORATION